Computerized Continuous Quality Improvement Methods used to Optimize Blood Transfusions

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ABSTRACT

Blood transfusion, although common, is not without risk and expense. Recently there has been a national focus on both ***overtransfusion*** *and* ***undertransfusion****. To provide the best quality of patient care, there must be a balance between* ***both over and undertransfusion****. We used a computer system to minimize* ***overtransfusion*** *by prompting physicians when orders that did not meet accepted criteria were made. Continuous quality improvement methods were used to optimize blood transfusions. We also evaluated* ***undertransfusions*** *by assessing patients who did not receive a red cell transfusion when the Hemoglobin or Hematocrit showed it was clearly indicated. Using our computerized alerting system we are able to promptly notify physicians when such conditions exist.*

Results of the blood ordering show that ***overtransfusions*** *of red cells have been minimized. Reductions in both mean Hematocrit and the standard deviation have occurred as predicted by continuous quality improvement theory. Assessment of* ***undertransfusions*** *showed that it was a minimal problem, but one that can be easily addressed with our laboratory alerting system.*

INTRODUCTION

The safety and use of blood transfusion products from either community donors or designated donors has become a major concern for both the public and physicians. The recent identification of the risk of transmission of human immuno-deficiency virus (HIV) with transfusions has further emphasized this concern. On the one hand there is concern about *overtransfusion* with its attendant risks and costs. On the other hand there is growing concern that we may be *undertransfusing* patients who desperately need transfusions. Though the overall risk of blood transfusion remains low, there is a need for physicians and other health care providers to use blood judiciously. To provide the best quality of care there needs to be a balance of concern for *both over and undertransfusion.*

Beginning in June of 1987 a computerized blood ordering system was implemented at LDS Hospital in Salt Lake City, Utah [1,2]. The blood ordering system was initially implemented to critique blood orders to be certain that those orders met specific patient transfusion related criteria, thus discouraging overtransfusion. During the same time period a computerized patient laboratory alerting system was implemented [3,4]. The laboratory alerting system provided feedback mechanisms to inform nursing staff of a patient's life threatening laboratory results. These two systems have now been combined to create a computer system that can both alert when there is need for a transfusion, and critique physician blood orders to minimize overtransfusion.

In this paper we report results of our study of blood transfusion practices at LDS Hospital. In the study, we used red blood cell transfusion as a test model since: 1) more than two-thirds of the blood products ordered at LDS Hospital are for packed red cells, 2) data justifying red cell transfusions are frequently measured (Hemoglobin, Hematocrit, Blood Pressure, Heart Rate and Arterial Oxygen Saturation) and available in the HELP computer system, and 3) consensus on the criteria for red cell transfusion are becoming more refined and better established [5-9].

MATERIALS and METHODS

LDS Hospital is a private, not-for-profit 520 bed tertiary care facility located in Salt Lake City, Utah. The medical staff of over 500 active physicians is supplemented by fellows, residents, and medical students affiliated with the University of Utah School of Medicine. The HELP computer system, a comprehensive hospital information system, was developed at LDS Hospital [10].

In June of 1987, using the HELP system, a computerized blood ordering system was implemented. The blood ordering system was developed to satisfy requirements of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). Criteria for appropriateness of each blood product were

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formulated by the medical staff using criteria found in the literature and adapted for Salt Lake City's 4,600 foot altitude. Since the initial implementation several minor refinements in criterion have occurred [1,2].

Computerized blood ordering by physicians or nurses has been in routine clinical operation since June of 1987. Quarterly reports of the use of all blood products ordered and dispensed have been kept. The clinical justification for each blood order have also been recorded. All orders are stored in the patient file as well as in a special blood order log. The order record has 65 data elements and provides comprehensive documentation and justification for each blood order request. Data used by the computerized critiquing system and stored in the order record include the following: 1) Blood Bank Ordering Module -- Notifies if blood is already on order; 2) Admit-Discharge-Transfer Module -- Patient age and gender; 3) Clinical Laboratory -- Hematocrit (Hct) and Hemoglobin (Hb) from the Complete Blood Count (CBC), platelets, prothrombin time (PT), and Partial Thrombin Time (PTT); 4) Surgery Schedule Module -- Procedures scheduled; 5) Nursing and ICU Module -- Vital signs; 6) Bedside Monitors in the Intensive Care Unit (ICU) -- heart rate, blood pressure and pulse oximetry; 7) Blood Gas Laboratory - Hemoglobin (Hb), Oxygen saturation and; 8) Physician and nurse entry of the "bleeding" status of the patient.

To evaluate the effectiveness of the system we have conducted experiments to detect both overtransfusion and undertransfusions.

Overtransfusions

The principal reason for implementing the computerized blood ordering system was to prevent overtransfusions. For each blood order, the physician or nurse ordering the blood must indicate the reason for ordering the blood at a computer prompt. If the blood order is for Anemia and the patient's most recent laboratory findings DO NOT show a Hemoglobin of less than 10 g/dL OR a Hematocrit of below 30%, a prompt is presented to the ordering person that the "order does not meet LDS Hospital criteria for packed cells for Anemia." If they still wish to make the order they are required to give a "freetext" over-ride reason. Each over-ride reason is reviewed the next day by the quality resources department. Quarterly individual physicians statistics are presented to each departmental medical director. If necessary, the departmental chief will have a private consultation with physicians who have major non-compliance problems. However, this has occurred only rarely in the nearly 6 years of operation of the computerized ordering system. Usually presenting the results to individual physicians has been sufficient. There has been little need to place physicians under sanction.

To assess if there was overtransfusion, we looked at the hematocrit data for patients who had red blood cell products ordered for Anemia. These data were analyzed in two ways: 1) by plotting yearly Hematocrit results for patients with packed red cells ordered who were classified by clinicians as needing blood because they were anemic are plotted, and 2) by comparing Hematocrit results for Anemia orders made in the 4th Quarter of 1988 and the 4th Quarter of 1992 (a period over which the Anemia transfusion criteria were stable).

Undertransfusions

Recently the Director of the National Heart, Lung and Blood Institute of the National Institutes of Health and others have warned that many patients may be undertransfused [11-16]. To assess the magnitude of undertransfusion, we evaluated every patient who had a Hematocrit of less than 21% OR a Hemoglobin of less than 7g/dL for the 1st Quarter of 1992 (January 1, 1992 to March 31, 1992). These values are clear indications of the need for red cell transfusion at our altitude. Patients meeting these criteria were ascertained by searching the HELP computerized data base. The electronic medical record of each patient who met the above noted transfusion criteria AND had **NO** orders for packed red blood cells was evaluated.

RESULTS

Overtransfusion

Using data from the computerized blood ordering system, we have monitored patient's hemoglobin and hematocrit for each red blood cell order due to Anemia since 1987. Figure 1 shows a plot of the hematocrit for Anemia Transfusion orders for that time interval. Note that although the Hematocrit "rule" for Anemia was 30% in 1987, the average transfusion Hematocrit was 28.3%, well below the "rule." Also note that the average transfusion hematocrit has fallen almost continuously since that time until it was 26.0% in 1992.

We also looked at the changes in transfusion practice between the 4th Quarter 1988 and the 4th Quarter of 1992. The theory of Continuous Quality Improvement predicts that, with standardization of blood ordering criteria, there would be a drop in mean Hematocrit and a reduction in the standard deviation of the

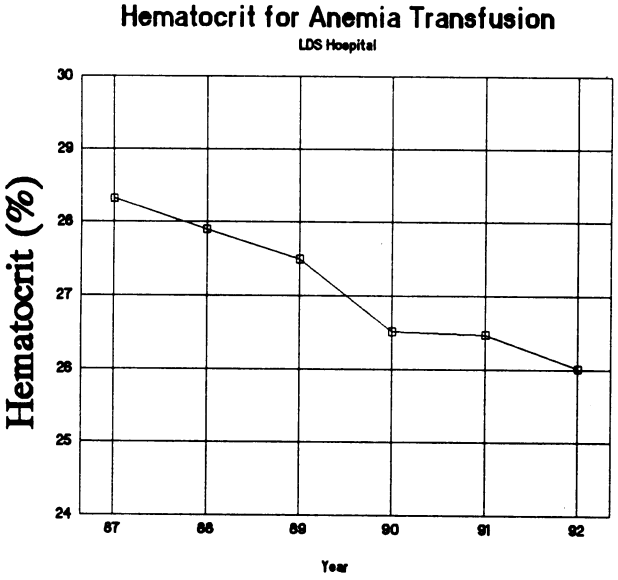

Figure 1. Plot of average Hematocrit levels for blood orders for Anemia at LDS Hospital from 1987 to 1992.

Hematocrit [17]. To determine if this had occurred, we carefully evaluated the change in transfusion practice for Anemia between the 4th Quarter of 1988 and the 4th Quarter of 1992. These results are shown graphically in Figures 2 and 3.

As shown in the Figures, there was a major reduction in average Hematocrit over this time interval principally because the number of transfusions for Hematocrits above 29% was dramatically reduced. Also note that the average transfusion Hematocrit fell from 27.65% in Quarter 4 of 1988 to 25.83% in Quarter 4 of 1992 with a ($p < 0.0001$). In addition, the standard deviation dropped from 4.13 in Quarter 4 of 1988 to 3.44 in Quarter 4 of 1992 (Analysis of Variance $p < 0.001$).

In March of 1992, the American College of Physicians published Clinical Guidelines for elective red blood cell transfusion and an accompanying justification article in the Annals of Internal Medicine [6,7]. The Clinical Guidelines made recommendations for further reducing criteria for red blood cell transfusion to a Hemoglobin of 7 g/dL or a Hematocrit of 21% for patients with Anemia. The Hemoglobin reduction from 10 to 7 g/dL and Hematocrit reduction from 30 to 21% was recommended because "the remarkable human tolerance of Anemia suggests that clinicians can accept hemoglobin levels below 7 in most patient with self-limited Anemia" [6,7].

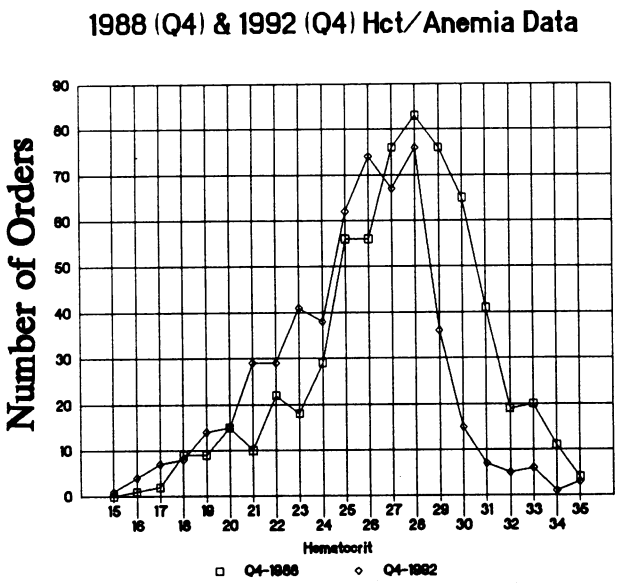

Figure 2. Plot of number of red blood cell orders for the 4th quarters of 1988 and 1992 for LDS Hospital. Note major "left shift" or reduction of the number of blood orders, especially for Hematocrits greater than 29%.

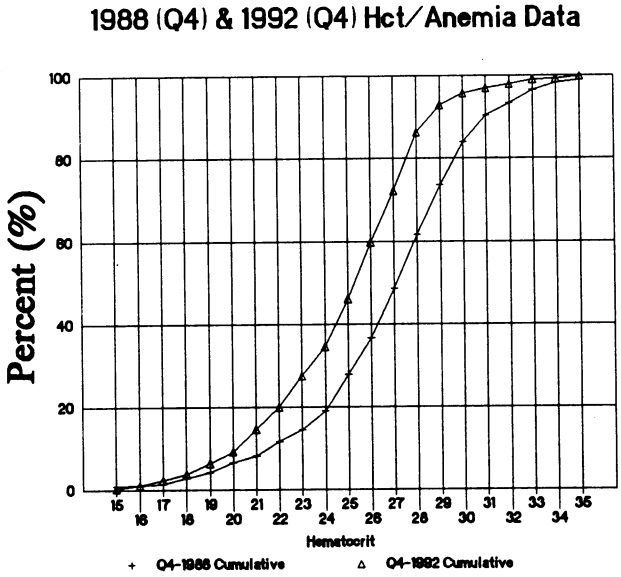

Figure 3. Cumulative plot of the results shown in Figure 2.

Undertransfusion

From a search of the HELP patient database, we determined that for the 1st Quarter of 1992 there were 29 patient encounters where there was a Hematocrit of less than 21% or a Hemoglobin < 7 g/dL with **NO** record of red blood cell transfusion. Two of these patients each had 2 encounters during the time interval. The remaining 27 patient's paper charts were manually reviewed.

Of these 27 patients, 7 patients had received red cell transfusions that were not noted in the HELP system because the transfusions occurred outside LDS Hospital. Four patients had Hct or Hb laboratory errors that were re-run and after the errors were corrected these patient's data did not meet the Anemia transfusion criteria. For the remaining 16 patients, 2 had charts that were not available because one was on IV Home care and the other was a series Radiology patient.

The 14 remaining cases consisted of 4 Males and 10 Females, with a mean age of 40 years (minimum 25, maximum 79). Eight of the 14 patients (57%) were either kidney transplant patients (4) or receiving renal dialysis (4). One of the kidney transplant patients had requested NO transfusions. The "kidney" patients had all adapted to the chronic lower hemoglobin levels and were physiologically functional. Three of the 6 patients not receiving transfusions or dialysis were seen in our emergency room. The first had a Hct of 15% and was transferred to our emergency room from a drug/alcohol detoxification facility. The patient arrived in critical condition, had a cardiopulmonary arrest, the emergency room physicians and nurses were unable to resuscitate the patient and he expired. The second emergency patient had a "sickle cell crisis" and was a patient whose typical Hct was in the low 20's. The third emergency room patient had a leg wound from a cocaine injection but the low Hematocrit situation was NOT addressed in the medical record.

Of the remaining 3 patients, 2 were Obstetrics patients who had a Dilation and Curettage (D&C) procedure performed. One had a Hematocrit of 16.3%, but the patient requested that there be **NO** transfusion. The second patient had a Hematocrit of 20.5%, was 25 years old and was asymptomatic. The final patient was a 79 year old who was admitted to our "short stay unit" for cystoscopy. The patient was readmitted 6 days later for an adenocarcinoma of the prostate and received 4 units of packed cells prior to surgery.

We concluded from this study that there was **NOT** a major undertransfusion of red cells at our hospital. Of the 29 situations, there was only one case of concern -- the patient with the emergency visit related to a cocaine injection.

CONCLUSIONS

Connelly and his associates at the University of Minnesota have used computerzed expert systems to critique platelet requests with excellent success [18]. Expert computer systems clearly have a "place" in helping physicians with blood ordering. Over a 6 year period there has been a dramatic reduction in the average transfusion Hematocrit for Anemic patients at LDS Hospital. As these reductions in Hematocrit have occurred there has not been an increase in the risk of patients ***needing*** but not receiving red cell transfusions. The combination of an expert system blood ordering program that makes recommendations about ***overtransfusing*** and a laboratory alerting system that warns of critically low Hematocrit or Hemoglobin levels appears to be a major contributor to this situation. Other investigators have found that computerized laboratory alerting systems are effective in improving physician behavior when treating life threatening laboratory conditions [19,20].

Several have suggested that "good clinical judgement" should be used to detect the need for transfusions rather than rule-based expert systems. In our experience with computerized blood ordering, we have seen a wide range in what is considered "good clinical judgement," and feel that the term must be better defined. For example, some physicians may consider transfusing a patient with a Hematocrit of 39% for Anemia "good clinical judgement" even though recent guidelines developed by medical experts suggest Hematocrits of 21% [6,7]

The Clinical Guidelines committee of the American College of Physicians has developed guidelines for "Prudent Strategies for Elective Red Blood Cell Transfusion" [6,7]. Their recommendations suggest that a Hematocrit of less than 21% or a Hemoglobin of less than 7.0 g/dL be used as a threshold for transfusion because of "the remarkable human tolerance of Anemia." In response to these recommendations we at LDS Hospital are now implementing red cell transfusion thresholds criteria -- Hematocrits of less than 24% OR Hemoglobin of less than 8 g/dL. These criteria are a not as confining as the 21% and 7 g/dL recommended in the Clinical Guideline and are appropriate for the 4,600 foot altitude of Salt Lake City.

We predict that changes in "anemic" status of the magnitude noted above will be difficult for our medical staff to accept. Just a decade ago it was acceptable at our hospital to both give and receive blood with a Hematocrit of 39! Also debate and supporting scientific evidence on what an appropriate Hematocrit and Hemoglobin for safe red cell transfusion are still being generated [9,11-16].

With computerized blood ordering we have

minimized overtransfusions. In addition, reductions in both the mean and standard deviation of the Hematocrit from 1988 to 1992 shows that the continuous quality improvement process is working well. Undertransfusions likely rarely occur because of laboratory alerting and fast and easy availability of laboratory findings on the HELP system.

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